AP Biology Exam Review Packet

1. Outlines of All Course Material

2. Most Significant Topics

3. Vocabulary by Topic

4. Part 1 Exam Strategies

5. Part 2 Exam Strategies

6. Data Interpretation & Analysis

Unit 1 Outline

I. Evolution – Organisms & Adaptations

a. **Evolution** happens when a **population's genome changes**: descent with modification
b. Natural variations among organism **phenotypes** due to differences in DNA (**Genotypes**). This genetic variation happens **randomly** (mutations) and is a key factor for natural selection to operate. Advantageous genes do NOT arise "upon request"
c. Adaptations are only defined by their **environments**
    Ex. Antibiotic resistance genes in bacteria are beneficial in an environment with antibiotics but could be too costly to maintain in an environment without antibiotics.
d. Adaptations result in **differential reproductive success** – more offspring left by certain members of the population…leads to **natural selection** – survival of the fittest
e. **Artificial selection** produces traits humans desire, not adaptations

II. Mechanisms of Evolution

1. **Natural Selection** 2. **Genetic Drift** (Random chance of success or failure)
3. **Non-Random mating** (Choosing mates based on some preference)
4. **Migrations**/Gene Flow 5. **Mutations** (Changes in DNA)

III. Modeling & Measuring Evolution

a. Hardy-Weinberg (HW) Model Formulas: **1. $p^2 + 2pq + q^2 = 1$ & 2. $p + q = 1$**
b. Measures changes in 1. genotype frequencies & 2. allele frequencies
c. If no change occurs from 1 generation to the next, evolution did not happen. Only way this happens is if the 5 mechanisms above are not occurring.

p^2 = prop. of HD individuals $2pq$ = prop. of HET individuals q^2 = prop. of HR individuals

p = prop. of dominant alleles q = prop. of recessive alleles

IV. Evidence for Evolution

a. **Genetic Data** – Similarities & Differences in DNA/Proteins
b. **Biomolecule Data** – All life as we know it needs water and chemicals for energy
c. **Physical structures** – Similar **homologous** traits, embryology shows evolutionary similarities. Similar structures not due to homology are called **analogous structures** (wings of bird vs. insect)
d. **Fossil studies** & **Radiometric dating** show general age/timeframes
All of these can be used to construct **phylogenies**
*Branched diagrams showing points of evolution, closer organisms share more features. Exact locations cannot be determined if data not provided, only analyzed based on relative closeness within the diagram.

V. Conserved Features

a. ALL ORGANISMS - **DNA/RNA Genetic Code**, Glycolysis
b. Photosynthesis in plants, some bacteria, algae
c. **Eukaryotes** – Organelles, Linear Chromosomes
d. **Endosymbiotic theory** reveals DNA and ribosomes in eukaryote organelles (chloroplasts and mitochondria) are more similar to prokaryotes than to their eukaryote "hosts"!!!!!! Infers that our organelles are the result of a symbiosis between many cells at some point in time.

VI. Speciation & Extinction

a. **Speciation** usually results from **reproductive isolation** (Sexually reproducing organisms)
At least 1 gene must change to affect a phenotype
b. **Pre-zygotic** Vs. **Post-zygotic** reproductive barriers
c. Also result from **geologic events & mutations**
d. **5 mass extinctions** – times of major geologic activity, species not adapted died out

VII. Origins on Earth

a. **4.6 BYA Earth forms, 3.5 BYA earliest fossils**
b. Inorganic molecules evolved into organic molecules to become building blocks for life
c. Low oxygen so first organisms probably anaerobic and chemosynthetic

Unit 2.1 Outline

I. Energy Basics

1. Maintaining order requires energy, based in laws of thermodynamics
2. 1st law: Energy not created or destroyed, only transferred or transformed
    a. Potential to kinetic b. Radiant to Chemical
    c. Energy value in transfers/transformations is Enthalpy (H)
3. 2nd law: Matter becomes disordered spontaneously
    a. Randomness value is called Entropy (S)
4. $\Delta G = \Delta H - T\Delta S$
   Positive G = Endergonic (requires energy) Negative G = Exergonic (releases energy)
5. Coupling reactions and stepwise reactions are most efficient

II. Energy Conservation Strategies

1. Temperature regulation – Ectothermy & Endothermy

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{t_2 - t_1}}$$

t_2 = higher temperature k_2 = metabolic rate at t_2
t_1 = lower temperature k_1 = metabolic rate at t_1

2. For every 10°C change in temperature that occurs, a corresponding change in metabolic rate occurs. **The change factor (Q_{10}) is usually 2-3 in biological systems**.
3. Size & Metabolism
    a. Size is inversely proportional to energy demands (heat loss)
4. Reproduction
    a. Seasonal b. life span c. Parental care

III. Energy Availability

1. Nutritional specialists vs. opportunistic feeders
2. Trophic levels ultimately depend of producers which rely on radiant energy
    a. Energy transformations only about 10% efficient though

IV. Methods of Energy Capture

1. Autotrophs: Inorganic energy sources 2. Heterotrophs: Organic energy sources

V. Metabolic Pathway Overview

1. Cellular Respiration: Transforms glucose and other pre-formed organic molecules into simpler molecules for cellular building blocks and in the process gain energy as ATP to perform cellular work
2. Fermentation: Same overall as respiration but not as efficient and less complex
3. Photosynthesis: Transforms CO_2 into organic molecules (sugars) by utilizing radiant energy
4. Molecule transformations require their electrons to move somewhere new. This process is facilitate by electron carriers.
5. Electron carriers gain electrons and become Reduced, but also drop off or lose their electrons and become Oxidized.
    a. $NADP^+ \rightarrow NADPH$ b. $NAD^+ \rightarrow NADH$ c. $FADH \rightarrow FADH_2$

VI. Aerobic Cellular Respiration

a. Glycolysis: Glucose → pyruvate, gain ATP & NADH Happens in Cytoplasm
b. Krebs Cycle: Pyruvate → Acetyl Co-A → into cycle. Cycle releases CO2, ATP, $FADH_2$ & NADH Happens in Mitochondrial matrix
c. Ox-Phos: NADH & $FADH_2$ drop off electrons to ETC on mitochondrial inner membrane. NAD^+ & FADH are regenerated for repeating their electron accepting functions.
Each electron energizes proton pumps that create an electrochemical gradient (chemiosmosis) of a large quantity of hydrogen ions in the intermembrane space. Ions exit the space via ATP Synthase channel, energy from their diffusion out is used to power ATP synthase which generates ATP.

VII. Fermentation

a. Glucose → pyruvate, gain ATP & NADH happens in Cytoplasm (GLYCOLYSIS)
b. Pyruvate → Lactic Acid or Ethanol, regenerates NAD^+ for repeating the cycle with new glucose molecules.

VIII. Photosynthesis

a. Pigments absorb specific wavelengths of light; the more various the pigments, the more energy absorption.
b. 2 parts of Photosynthesis:
    1. LDR – Energy capture & transfer 2. LIR – Energy used to make sugars
c. LDRs: Light "pushes" electrons out of PS2, electrons used to energize proton pumps on an ETC like in respiration. ATP generated in a similar fashion as well. This is called Photophosphorylation. Electrons keep moving through PS1 and reach NADP+ to form NADPH.
d. LIRs (Calvin Cycle)
    1. Fixation Phase: ATP (FROM LDRs) is used to join CO2 molecules to RuBP to form initial organic molecules.
    2. Reduction Phase: NADPH transfers electrons to organic precursors (which are thereby Reduced), some rearrangements happen, result in glucose molecules.
    3. Regeneration Phase: Some glucose stored for energy while remaining used to regenerate initial RuBP molecules with the energy from ATP (FROM LDRs).

IX. Evolution of Photosynthesis and Other Pathways

a. Photosynthesis evolved 3.5 bya in bacteria
b. Toxicity favored its release from cells
c. Converted atmosphere from Anaerobic to Aerobic
d. Populations evolved to utilize this oxygen, died out or live in anaerobic conditions today.

Unit 2.2 Outline

I. Matter in Organisms & the Biosphere

1. SPONCH used to make the 4 macromolecule types
   Carbohydrates, Lipids, Proteins, Nucleic Acids
2. SPONCH cycles through the environment
   Nitrogen Cycle, Carbon Cycle, Phosphorous Cycle, Water Cycle

II. Carbon & Water

1. Carbon is Tetravalent: forms 4 covalent bonds with itself or other atoms, can be 1x, 2x, or 3x bonds
2. Allows for endless arrangements, shapes, and lengths.
3. Water is polar: Electronegativity differences cause partial negative on oxygen, each hydrogen is partially positive.
4. Polarity results in cohesion, adhesion, good solubility, and high specific heat (resistant to phase changes).

III. Exchanges with Environment

1. Cells must be small to increase transfer efficiency.
2. Adaptations for increasing SA: Root hairs in plants, microvilli in intestines, alveoli in lungs.

IV. Membranes & Cell Walls

1. Fatty acids are non-polar/hydrophobic 2. Phosphate heads are hydrophilic/polar.
2. Polar regions encounter water while non-polar parts congregate away from water…forms a lipid BI-LAYER.
3. Proteins, carbohydrates, etc. are embedded in the membrane making it "fluid" (NOT SOLID) so molecules can move in and out of the membrane.
4. Cell walls of cellulose or chitin provide extra stability but pose problems for transport.
5. Internal membranes (Mitochondria, chloroplasts) facilitate cell processes.

V. Transport Through Membranes

1. Passive Transport: Movement without energy (ATP). Molecules move from areas of high concentration to low concentration (WITH concentration gradient).
   a. Simple Diffusion: N_2, CO_2, O_2 b. Facilitated diffusion: Channel proteins allow movement through channels - Lipid-insoluble compounds (Ions, sugars, some proteins)
   OSMOSIS: Water moves from areas of low SOLUTE concentration (HIGH water potential) to areas of HIGH solute concentration (LOW water potential).
   Water Potential calculations $\Psi = \Psi p + \Psi s$ $\Psi s = -iCRT$
   Hypertonic Vs. Hypotonic Vs. Isotonic
2. Active Transport: Movement requiring energy (ATP). Molecules move from areas of low concentration to high concentration (AGAINST concentration gradient).
   a. Proton pumps b. Gated Channels c. Receptor-Mediated Endocytosis
   d. Endocytosis e. Exocytosis

Unit 2.3 Outline

I. Biological Disruptions

- Organisms face a variety of **disruptions** at all levels
  - Cells, ecosystems, organs
- Mechanisms to maintain balance can be **physiological or behavioral**
  - Hibernation vs. Shivering/Sweating
- Regulation mechanisms reflect common ancestry
  - Migration patterns, Various body systems

II. Feedback mechanisms

- Maintain internal environments & allow for response to change.
- Crucial for all cellular responses: Enzyme regulation, hormone regulation, DNA regulation
- **Negative Feedback** – A stimulus causes a response; the response is stopped when the normal condition is re-established.
  - Blood sugar regulation, body temperature regulation
- **Positive Feedback** – A stimulus causes a response; the response is amplified by the products formed by response; continues until "task" is completed.
  - Oxytocin during childbirth, Blood-Clotting

III. Immune Responses

- **Specific vs. Non-Specific** Responses
  - **Non-Specific immune responses**: Mechanisms to target/prevent a variety of pathogens
    - Also called Innate Immunity
    - External: Skin, mucous membranes, Secretions
    - Internal: Phagocytes, Antimicrobial proteins, Inflammatory response, Natural killer cells
  - **Specific immune responses**: Mechanisms to target/protect against specific pathogens
    - Also called Acquired Immunity
- **Specific Immune Responses**
  - Cell-Mediated Response – Infected **cells** are destroyed
    - Cytotoxic T cells, Intracellular pathogens (**VIRUSES** and some bacteria)
    - Signaled by antigens
    - Cytotoxic T cell binds to infected cell, releases perforin that causes holes in cell, **cell lyses and dies**
  - Humoral Response – Pathogens **outside of cells** targeted & destroyed
    - B cells bind to antigens, divide into plasma cells & memory cells
    - **Plasma cells** secrete **antibodies** that target & **mark pathogens** that phagocytes will be attracted to and destroy
    - **Memory cells** stay in the body and cause a much faster response if the same pathogen infects again

IV. Mechanisms to Regulate Timing & Coordination of Events

1. Organism Development – Cells start out as **Totipotent**, then begin to differentiate & lose the ability to become any cell type after set points.

- Majority of cells **have the same DNA but end up different due to differential gene expression**.
- Regulated by **Transcription factors, Inductive signals**, and various other regulatory molecules
    - **Transcription Factors** – Any molecule that will cause DNA to be transcribed a certain way
        - Are distributed differently during cell division (Asymmetric distribution)
        - These differently expressed cells now have different molecules that can be used to signal other cells to divide more/less/produce different molecules
        - This is called Inductive Signaling
    - **Inductive Signaling** – The actual division of cells can lead to specific cells being in contact with some but not others; this is crucial to development
    - **HOX genes** used to determine body plans, any mutation in these genes are **lethal**
    - **miRNA** – degrades or blocks mRNA from being translated; essential to some cells having more or less of a transcription factor and hence developing into its specific cell type
    - **Apoptosis** – programmed cell death

2. Physiological Responses

- Plants: **Phototropism & Photoperiodism** rely on hormones
- Animals: Timing coordinated by **hormones** (sleep-cycles/mating seasons)
- Bacteria: **Quorum sensing** based on environmental conditions
- Fungi: **Reproductive** response to environment stability

3. Behavioral Responses

- Essential to **natural selection**
- Can be **inherited**, **learned** or a combination of both
- Learned behaviors – Through socialization or trial & error
- Innate (genetic) Behaviors – Babies crying is not learned, Courtship among birds/insects is not learned
- Many organism populations can **cooperate** which provides a better mechanism for survival
    - Meerkats, Prairie Dogs, Bees, Wolves

Unit 3.1 Outline

I. Genetic Information

- DNA is **primary** carrier of genetic information except in some viruses which use RNA
- DNA & RNA have variability in structure = **Diversity** = good for coding information
- DNA & RNA have areas for hydrogen bonding = good for **temporary** bonds = good for decoding their information & **replicating easily**
- DNA is coiled with proteins to form **nucleosomes**. Nucleosomes condense tightly to form **chromosomes**
  - *Eukaryotes = multiple linear chromosomes*
  - *Prokaryotes & Viruses = Single circular chromosome*
- Other circular DNA found in **Mitochondria**, **Chloroplasts** & **Plasmids**

II. Nucleic Acid Structure

- DNA & RNA made of **nucleotides**. Nucleotides have a phosphate, nitrogen base & sugar
- Nucleotides can have nitrogen bases with 2 rings = Purines or 1 ring = pyrimidines
  - **Adenine & Guanine** are purines
  - **Cytosine, Uracil & Thymine** are pyrimidines
- Base pairing **A-T** (2 H-bonds) and **G-C** (3 H-bonds *more stable*)
- Nucleotides always bond by the phosphate (5' end) of one nucleotide joined to the sugar hydroxyl group (3' end) of a second nucleotide.
- 2 DNA strands joined in a double helix, strands run **antiparallel** (opposite directions)

III. DNA Replication

- Prokaryotes have a **single origin of replication** where replication begins
- Eukaryotes have **multiple origins of replication**, so the process can happen in a timely manner
- Replication Steps
  - **Helicase** separates strands
  - RNA primer synthesized as a starting point
  - Leading strand grows continuously towards the replication fork as the DNA continues to unwind
  - Lagging strand grows discontinuously away from the replication fork in segments.
    - Each segment = **Okazaki Fragment**
    - Each segment requires a new RNA primer
  - **New nucleotides always added to the 3' end ONLY by *DNA Polymerase* = 5'→ 3" additions**
  - Polymerization requires each nucleotide monomer to be phosphorylated 2x to gain energy for the addition reaction…2 ATP are required for each nucleotide added
  - RNA primers are replaced with DNA & segments joined by **DNA Ligase**

IV. Protein Synthesis

- DNA sequences are instructions to make **proteins**
- Requires **Ribosomes & RNA**
  - RNA is **single** helix, **ribose** instead of deoxyribose, and uses **Uracil** instead of Thymine
  - mRNA - result of transcription of DNA
  - rRNA - part of ribosomes
  - tRNA – transfers amino acids to ribosomes for proteins to be created

- Transcription Steps
  - **RNA polymerase** attaches to DNA **promoter sequence** & starts unwinding DNA
  - **Reads DNA template strand 3' → 5' and transcribes into mRNA 5' → 3'**
- Modifications
  - **Spiceosome** excises **introns** and links together required gene segments (**exons**)
  - 3' poly-A tails & 5' GTP cap assist in export from nucleus & keep mRNA from being degraded in cytoplasm
- Translation Steps
  - Initiation: start **codon** (AUG) read by ribosome (**5' end read first**) signals tRNA to attach first **anticodon** to first mRNA codon
  - Elongation: more codons read by ribosome signals more tRNAs to attach their anticodons to the next mRNA codons. All linked together via ATP energy by peptide bonds.
  - Termination: stop codon signals end of translation and protein is released from ribosome.
  - **Proteins produced by free ribosomes in cytoplasm stay in the cell**
  - **Proteins produced on the Rough ER are exported or become part of a membrane**
- Retroviruses use **reverse transcriptase** to perform protein synthesis in a modified fashion.

V. DNA Technology

- **Genetic Engineering** is any method of **artificially** changing the DNA sequence of organisms
- DNA is extracted, cut with restriction enzymes, separated and sequenced
- Cloning
- Genes can be combined from different organisms = **recombinant DNA**
  - Artificial enzymes, hormones, receptors for "faulty" organisms
  - Requires amplification for large quantities = **PCR**
  - Organisms can undergo **transformation** if they take in foreign DNA & it becomes a part of their genome
  - **Transgenic organisms** have genes from other organisms
    - Medicines, food supply, bioremediation of oil spills, textiles

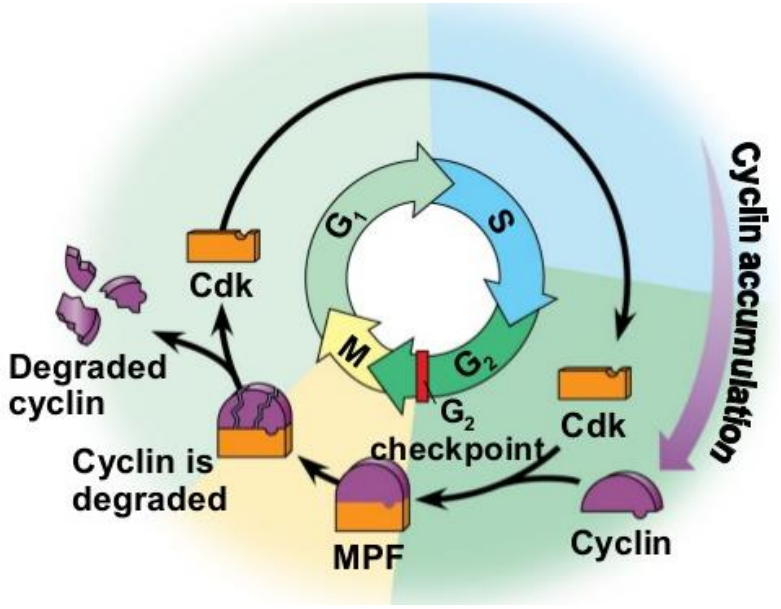
Unit 3.2 Outline

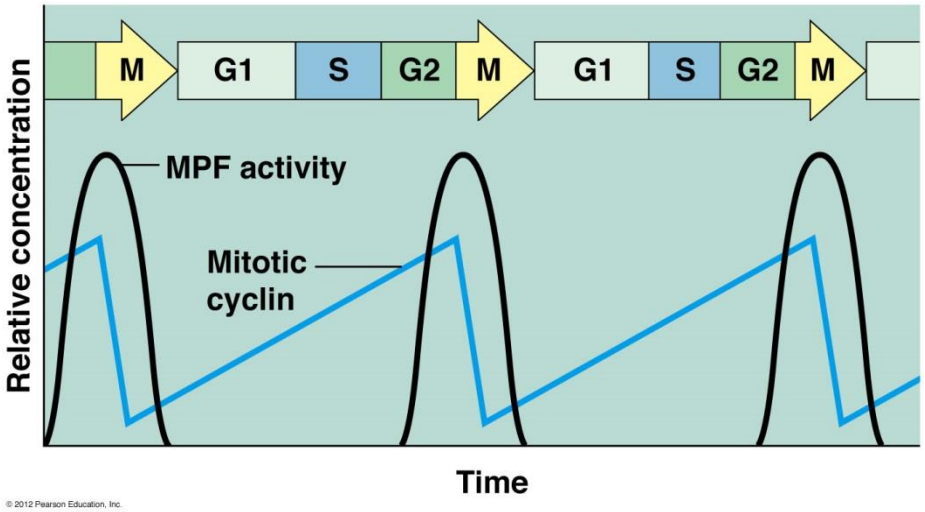
I. Cell Division Roles

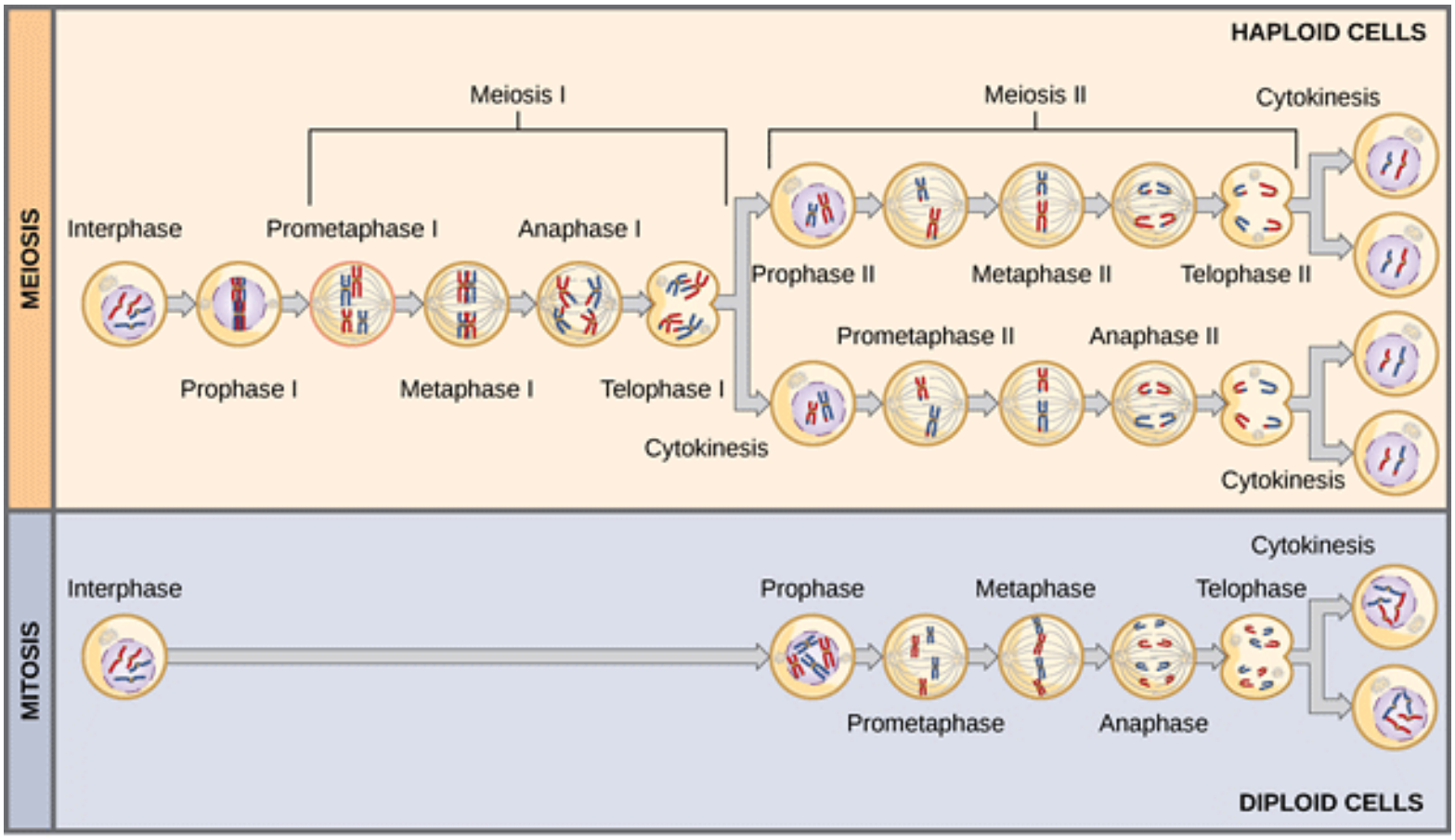
A. Somatic cells – diploid (2n), identical, produced by MITOSIS
B. Gametes – haploid (n), genetically diverse, produced by MEIOSIS

II. Cell Cycle & Regulation

A. Cell Cycle composed of G1 + S + G2 = (INTERPHASE) & M Phase
S phase replicates DNA, G phases prepare for division, M phase chromosomes & cell divide
B. Proteins regulate movement through cycle
C. Tumors result from loss of cell cycle regulation, cells dividing uncontrolled.







						OUTCOME
PROCESS	DNA synthesis	Synapsis of homologous chromosomes	Crossover	Homologous chromosomes line up at metaphase plate	Sister chromatids line up at metaphase plate	Number and genetic composition of daughter cells
MEIOSIS	Occurs in S phase of interphase	During prophase I	During prophase I	During metaphase I	During metaphase II	Four haploid cells at the end of meiosis II
MITOSIS	Occurs in S phase of interphase	Does not occur in mitosis	Does not occur in mitosis	Does not occur in mitosis	During metaphase	Two diploid cells at the end of mitosis

III. Inheritance Patterns

Simple Dominance
One trait dominant to other; heterozygote shows dominant phenotype.

Monohybrid cross

Hh x Hh = 3:1 phenotype ratio results in offspring

Dihybrid cross

HhBb x HhBb = 9:3:3:1 phenotype ratio results in offspring

Linked genes
2 different genes (traits) on a single chromosome
Distance between the 2 genes related to the frequency of recombination.
Recombination frequency in m.u. = # recombinants / total offspring

Other Influences on traits
If none of the patterns show up as expected, some other factors could be influencing

Polygenic Inheritance: Phenotype depends on multiple genes

Color of hair/fur – genes required for hair production, pigment type, keratin composition, etc.

Epistasis: Phenotype depends on external influences

Gender in some species depends on external temperature.

	Incomplete Dominance Example	Codominance Example	Multiple Alleles Example	Sex-linked Example
How are alleles expressed?	Each allele written by its own letter R = Red W = White	Each allele written by its own letter R = Red W = White	Each allele written by its own letter Example: A B O blood types	A superscript on the "X" chromosome. "Y" chromosome does not express the allele ***Hemophilia*** is an example X^H X^h Y
How many alleles are there?	2 (Red & White) RR = Red WW = White RW = Pink	2 (Red & White) RR = Red WW = White RW = Red/White Stripes	3 but only 2 will be in each genotype. (AO, AA, BA, OO, BB, BO but never ABO, BBA, etc.)	2 (Normal & Hemophilia) **Females** X^HX^H = Normal X^HX^h = Normal (carries allele but can't tell by appearance) X^hX^h = Has hemophilia **Males** X^HY= Normal X^hY= Has hemophilia
Which allele(s) is dominant?	Both but they mix to **form a blend.** Example: Red and white form pink blend; 2 red = red; 2 white = white.	Both but they both **show equally** Example: Red and white form red/white stripes; 2 red = red; 2 white = white.	2 codominant (A & B) to the 3rd recessive (O)	Depends on the trait; **males show significantly different outcomes than females.** Color blindness is recessive Cat fur color is codominant

Unit 3.3 Outline

I. Genome Changing Mechanisms

- Mechanisms of genome evolution (DNA Changes) among, bacteria, viruses and eukaryotes.
    - Transformation, Transduction, Conjugation, Mutations, Meiosis

II. Genome Regulation

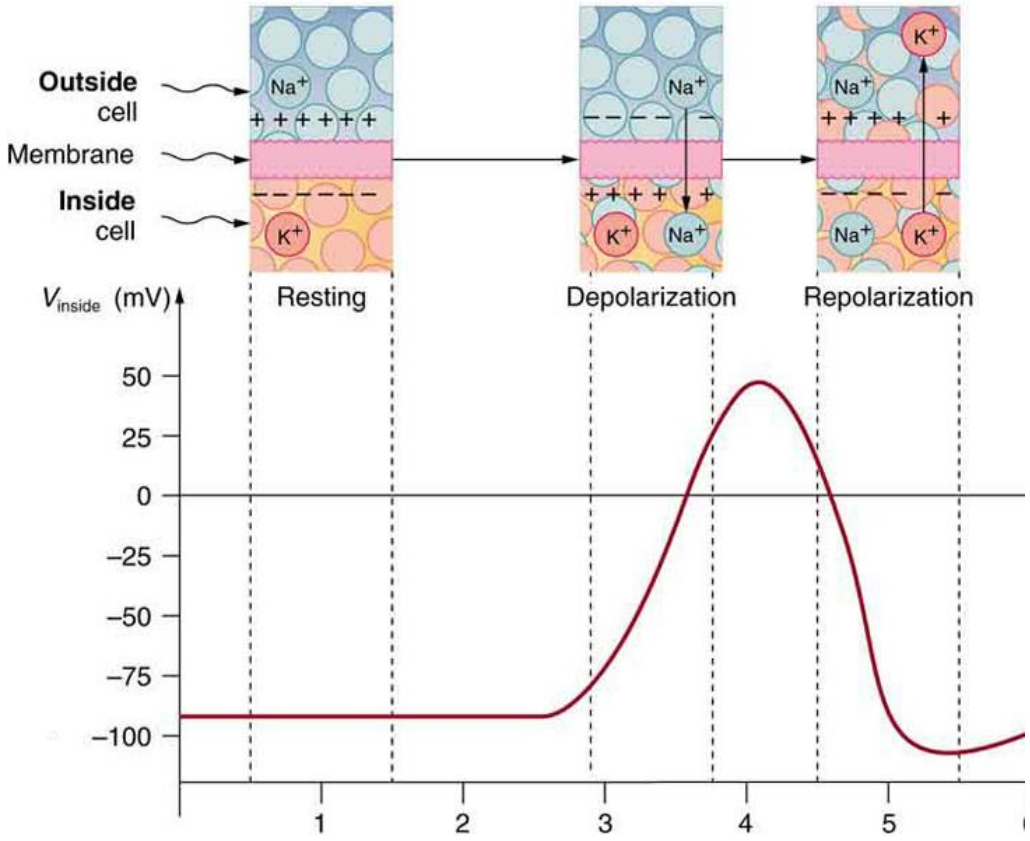
- Bacteria – Operons
    - Negative vs. Positive regulation
    - Repressible vs. Inducible
    - Repressor vs. Corepressor
    - Regulatory gene vs. Structural gene
- Eukaryotes
    - Chromatin Modifications –DNA/Histones
    - Enhancers, Transcription Factors, Chromatin Loops
    - Alternative Splicing, mRNA degradation, 5'cap, poly-A tail
    - Proteasome regulation
    - ncRNA, miRNA, siRNA

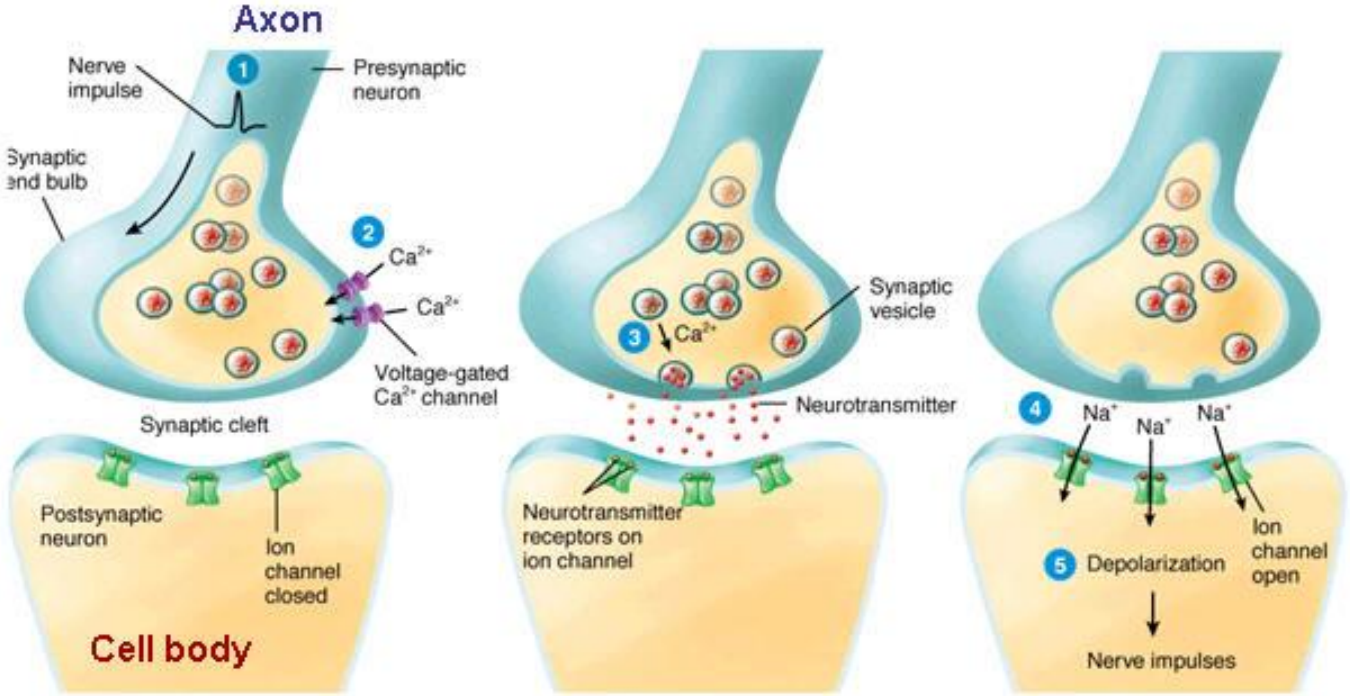
III. Signal Transduction Pathways

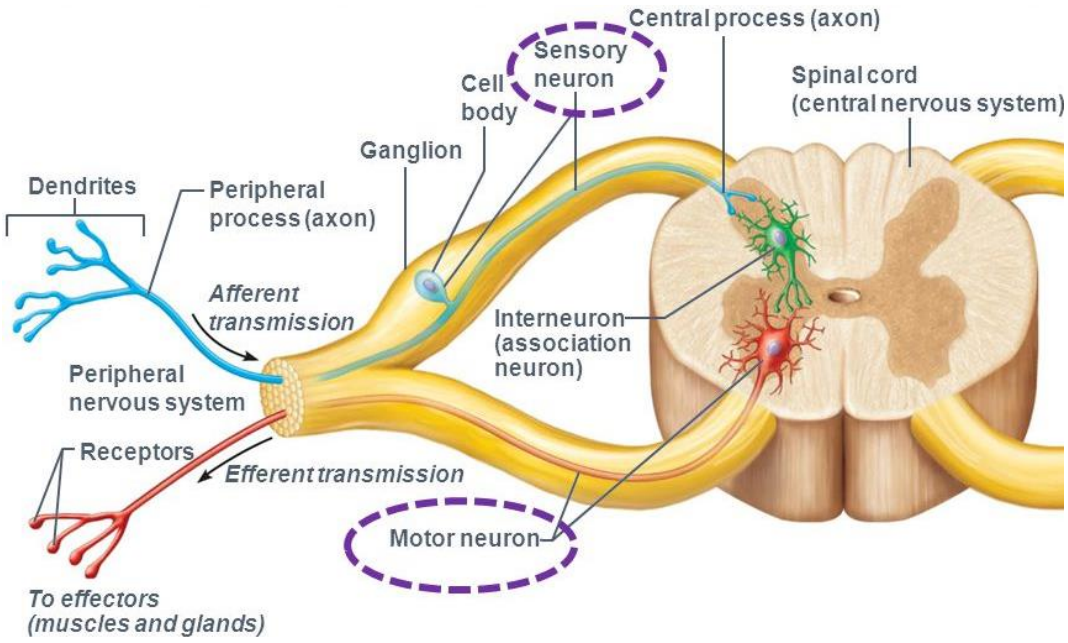
1. Reception
   Intracellular (lipid soluble ligands): directly bind to internal receptors & cause response.
   Membrane: G-Linked vs. Tyrosine Kinase – Ligand binds, causes receptor to change & transmit response inside cell.
2. Transduction
   Second Messengers: cAMP, Calcium, IP3
   Phosphorylation Cascades – Kinases add phosphates & activate molecules in pathway
3. Response
   Activate gene expression (result in new proteins by transcription)
   Activate a non-nuclear cellular response (metabolic)

IV. Nerve Signaling

1. Na+/K+ pump keeps resting potential (Na+ outside, rmp -70)
2. Dendrites receive stimuli that cause Na+ channels to open, leads to more openings & depolarization (Positive). Channels re-close (repolarization) after signal passes.
3. Signal travels down axon, reaches synaptic terminal.
4. Signal causes Ca+ to enter terminals, releases neurotransmitters from vesicles.
5. Vesicles exocytose neurotransmitter into synaptic cleft, travel to interneurons in CNS.
6. Response signal sent to an effector (muscles, etc.)


Outside cell
Membrane
Inside cell
Na+
K+
Resting
Depolarization
Repolarization
V_{inside} (mV)
50
25
0
–25
–50
–75
–100
1
2
3
4
5


Axon
Nerve impulse
Presynaptic neuron
Synaptic end bulb
Ca2+
Voltage-gated Ca2+ channel
Synaptic cleft
Postsynaptic neuron
Ion channel closed
Cell body
Synaptic vesicle
Neurotransmitter
Neurotransmitter receptors on ion channel
Na+
Depolarization
Ion channel open
Nerve impulses


Central process (axon)
Sensory neuron
Cell body
Spinal cord (central nervous system)
Ganglion
Dendrites
Peripheral process (axon)
Afferent transmission
Interneuron (association neuron)
Peripheral nervous system
Receptors
Efferent transmission
Motor neuron
To effectors (muscles and glands)

Unit 4.1 Outline

I. Molecule Interactions

- SPONCH all interact with each other & ions like Ca+, Na+, K+ & Cl- to produce complex molecules.
- Sequence & directionality lead to diversity
  - 3' & 5' ends of DNA, Fats vs. sugars, multiple amino acids
- Complex interactions = complex molecules
  - Levels of protein structure & endless varieties of proteins

II. Organelles

Cell Part Names	Functions	Cell Part Names	Functions
Cell Wall	Provide tough support around the membrane and prevents cell from bursting	Golgi Body	Packages proteins from Rough ER into vesicles
Plasma (Cell) Membrane	Form a barrier around the cell and helps move materials in and out of the cell	Vesicles	Transport proteins to the membrane for integration or secretion out of the cell
Cytoplasm	Provide a liquid for easier movement of materials in the cell	Smooth Endoplasmic Reticulum (ER)	Synthesize Lipids (Membranes, oils, hormones)
Chloroplasts	Photosynthesis: Where pigments are for photosynthesis to produce sugars	Central Vacuole	Store water, sugars and many other nutrients Provide pressure force like a balloon.
Mitochondria	Cell respiration: Where sugars are broken down for cells to get energy (ATP)	Nucleus	Contains DNA which encodes hereditary information for traits
Cytoplasm Ribosomes	Assemble amino acids into proteins for use within the cell	Nucleolus	Produces ribosomes
Rough Endoplasmic Reticulum (ER)	Contains ribosomes that assemble amino acids into proteins for use in the cell membrane or secretion from the cell	Centrioles	Organize Cell Division

III. Organ & Organ System Interactions

- Examples of importance include:
  - Transpiration in Plants – Roots, stems, leaves, guard cells,
  - Nerve signaling in animal responses – nerve membrane anatomy, integration with CNS, effectors (muscles, glands)
  - Respiration/Circulation in animals – Alveoli & capillaries in lungs; CO_2/O_2 exchange

IV. Population Dynamics

- Population Growth Calculations:
  - $r = b - d$ same as $dN/dt = B-D$

Exponential Growth: J-Shaped Curve
r- selection life histories

$$\Delta N/\Delta t = r_{max}N$$

Logistic Growth: S-Shaped Curve
K-selection life histories

$$r_{max}N\left(\frac{K-N}{K}\right)$$

- K = carrying capacity = factors that limit the size of populations (food, space, mates)
- Populations will increase until resources are short or predators/competition/parasites cause greater deaths than births. Success depends on a population's ability to overcome these factors based on their advantageous alleles, leading to differential reproductive success (NATURAL SELECTION)
- Population **DENSITY** most practical and useful for population studies; easier to measure than total population size.
- Density-Dependent Factors affect population more as density increases (parasites, disease, competition, etc.)
- Density-Independent Factors affect population same regardless of density (storms, temperature, etc.)

V. Energy Dynamics

- Energy flows through ecosystems from a source (sun/hydrothermal vents) to organisms but each transfer only retains **about 10%** with the remaining being transformed to heat or other non-usable forms.
- Matter cycles without being lost, but is converted (metabolism).
- **Producers** (autotrophs) don't produce carbon-based waste like heterotrophs do. The calculation below is used to determine their **NPP, or energy stored in their bodies available as food** versus the **GPP, or total chemical energy generated from photosynthesis.**
  - NPP = GPP – R
- **Consumers** (heterotrophs) do produce a lot of carbon-based waste so this must be accounted for in calculations as shown below.
  - NSP = GSP – (R + waste)

Unit 4.2 Outline

I. Enzymes

- Biological protein-based catalysts. **Active site** speeds up reactions by lowering E_a requirements
  - Orienting substrates, straining bonds, optimal environment
- Enzyme function dependent on environment and enzyme's structure based on its parts
  - Stomach enzymes are optimal at low pH since its structure is held together better & active site has acidic aspartate amino acids.
- Competition for active site/substrate
  - **Good during normal regulation** – allosteric regulators keep metabolic enzymes switched off when not needed.
  - **Bad with introduced chemicals** –allosteric or competitive inhibitors/activators can shut down/turn on permanently.
  - Non-competitive Inhibition decreases enzyme efficiency more than competitive inhibition.

II. Community Interactions

- Interaction types: Measured on who "Wins and Loses"

  1. Predation (+/-) 2. Herbivory (+/-) 3. Competition (+/-)

  Symbiosis: Interaction where both live closely together; harmful or beneficial

  1. Mutualism (+/+) 2. Parasitism (+/-)

  Mimicry: Organisms appear similar

  1. Batesian Mimicry – mimic is a fake of a harmful organism
  2. Mullerian Mimicry – 2 appear similar to each other, both harmful

III. Ecological Succession

a. Changes to ecosystems over time, where old organisms are replaced by newer organisms

b. Primary succession – soil is destroyed and must be re-established by **pioneer species**

Ex. Lava flows, Glaciers, New Islands

c. Secondary Succession – soil NOT destroyed but plants/animals must be re-established.

Ex. Fires, Deforestation, Farming

IV. Other Disturbances

- Invasive species out-compete natives due to lack of competition/predators.
- Habitat destruction
- Pollutants, agricultural runoff, global climate changes
- Loss of **Keystone species** – inherent to the community based on significant ecological role, despite its usually low abundance/noticeability.

Common Themes to Review/Remember

1. All life acts in ways that **improve their ability to survive & reproduce**. 99/100 questions about why an organism/population does certain things will lead to an answer involving **survival of the fittest/advantageous alleles or related information**. Any choice that is not aligned with this rule is incorrect.

2. Memorize the energy & matter transformations in **Photosynthesis & Cellular Respiration**
   a. Questions related to photosynthesis will always want you to know that light, water & CO_2 are requirements/used up while O_2 & glucose are products/increase
   b. Questions related to C.R. will always want you to know that O_2 & glucose are used/decrease & CO_2 & water are produced/increase.

3. Know **membrane transport types** & rationales underlying them

4. Memorize the steps/enzymes in **DNA replication** & **Protein synthesis**

5. Memorize key **inheritance patterns**, **linked gene patterns**

6. Review **cell cycle phases** & **regulation**

7. Know how **genomes** are **changed** & **regulated**

8. Memorize **signal transduction pathways** & **nerve signal mechanism**

9. Know the **10% rule** of energy flow in ecosystems
   Producers 100,000 → 1^o consumers 10,000 → 2^o consumers 1,000 → 3^o consumers 100

10. Memorize **organelle** structures/functions/relationships to each other & organism homeostasis

11. Memorize **enzyme** mechanisms of action, regulators/disruptors & rationales

12. Be familiar with **physiological processes** such as:
    Plant Transpiration Circulation & Gas Exchange mechanisms (O_2/CO_2 transfer)

13. Understand how **Negative Feedback** & **Positive Feedback** work & **examples of each**

Topic	Important Vocabulary
Evolution	Alleles, Gene Flow, Advantageous, Selective Advantage, Dominant, Recessive, Phenotype, Trait, Homozygous, Heterozygous, Homologous, Analogous, Species, Prezygotic, Postzygotic, Bottleneck, Genetic Drift, Eukaryote/Prokaryote, Differential Reproductive Success, Evolution, Natural Selection, Phylogeny, Radiometric Dating, Vestigial Structure
Bioenergetics	Exergonic, Endergonic, Ectotherm, Endotherm, Heterotroph, Autotroph, Electron Transport Chains, NADH/NADPH, ATP, Proton Pumps, Pigments, Mitochondria, Inner Membrane, Chloroplast, Thylakoid Membrane, Light Reactions/Calvin Cycle, Glycolysis/Krebs Cycle/OxPhos, Fermentation, H+, Chemiosmosis
Cell Transport	Concentration Gradients, Active Transport, Exocytosis, Endocytosis, H+ Pumps, Cotransport, Passive Transport, Diffusion, Facilitated Diffusion, Water Potential/Osmosis, Polar/Nonpopal, Hydrophobic/Hydrophillic, Lipid-Bilayer, Selective Permeability, Ions, Channel Protein, Integral Protein, Peripheral Protein, SA-V Ratio
Homeostasis	Homeostasis, Negative Feedback, Positive Feedback, Specific/Nonspecific Immunity, Helper T-Cells, Cytotoxic T-Cells, B-Cells, Antibodies, Inflammatory Response, Antigens, Pathogens, Macrophage, Lysis, Cytokines, Interleukins
Organism Development & Event Coordination	HOX genes, miRNA, Apoptosis, Induction, Differentiation, Differential Gene Expression, Cytoplasmic Determinants, Transcription Factors Phototropism, Photoperiodism, Nocturnal, Diurnal, Circadian Rhythm, Learned Behavior, Innate Behavior,

DNA Structure & Function	Replication, Semi-Conservative, Antiparallel, Helicase, DNA Polymerase, Ligase, 3' → 5' Synthesis, Transcription, RNA Polymerase, Codons, Spliceosome, mRNA, Translation, Anticodons, tRNA, Ribosomes, Reverse Transcriptase, Genetic Engineering, Recombinant DNA, PCR, Electrophoresis
Cell Cycle	Mitosis, Somatic Cell, Diploid, Meiosis, Gamete, Haploid, Crossing Over, Sister Chromatids, Homologous Chromosomes, Interphase, M-Phase, G1-Phase, G2-Phase, S-Phase, Cyclin, MPK, Cdk, Tumors/Cancer
Inheritance Patterns	Autosomes, Sex Chromosomes, Monohybrid, 3:1 Ratio, Dihybrid, 9:3:3:1 Ratio, Codominance, Incomplete Dominance, Dominant, Recessive, Genotype, Phenotype, Linked-Genes, m.u., Parental/Recombinant, Testcross, Multiple Alleles, Carrier, Epistasis, Polygenic Inheritance
Regulation of DNA Expression	Mutation, Point Mutation, Frameshift Mutation, Chromosome Mutation, Substitution, Deletion, Insertion, Translocation, Inversion, Transformation, Transduction, Conjugation, Recombination, Operons, Regulatory Genes, Structural Genes, Operator, Repressor, Corepressor, Repressible/Inducible, Negative/Positive Gene Regulation Start/Stop Codon, Poly-A Tail, 5' Cap, Alternative Splicing, Acetylation/Methylation, ncRNA, siRNA, miRNA, Enhancer, Activator, Promoter, Transcription Factors
Signaling Pathways	Reception, Ligand, Intracellular Receptor, Trans-Membrane Protein, G-Linked/TyrK Receptors, Transduction, Kinase, Phosphatase, Phosphorylation Cascade, Second Messenger, IP3, cAMP, Adenylyl Cyclase, Nuclear Response, Cellular Response, Hormone, Endocrine Gland, Insulin, Glucagon, Epinephrine, Testosterone, Estrogen, TSH, Oxytocin, Melatonin, ADH Na+/K+ Pump, Resting Potential, -70mV, Action Potential, Voltage-Gated Channel, Sensory Neuron, Dendrite, Axon, Synaptic Terminals, Synapse, Neurotransmitter, Vesicle, Depolarization, Repolarization, Hyperpolarization, Threshold, Stimulus, Interneuron, Integration, Motor Neuron, Effector

Biomolecules	SPONCH, Monosaccharides, Polysaccharides, Carbohydrates, Fatty Acids, Glycerol, Phospholipids, Triglycerides, Saturated/Unsaturated Fats, Cholesterol, Nucleotides, Nucleic Acids, Amino Acids, Proteins/Polypeptides, Primary structure, Secondary structure, α-helix, β-sheet, Tertiary structure, Covalent bond, Disulfide Bond, Hydrophobic Interaction, Quaternary Structure, Peptide Bond, Dehydration Synthesis, Hydrolysis
Enzymes	Catalyst, Enzyme, Substrate, active site, allosteric site, cooperativity, pH, Non-competitive inhibitor, competitive inhibitor, Vmax, Km, Activation Energy, allosteric regulator, allosteric activator, cooperativity
Cell Parts	Organelle, Nucleus, Nucleolus, Cytoplasm, Ribosomes, Rough ER, Golgi, Vesicles, Smooth ER, Lysosomes, Centrioles, Cytoskeleton, ECM, Plasmodesmata, Gap Junctions, Cell Wall, Mitochondria, Chloroplast, Cilia, Flagella, Nucleoid, Vacuole
Plant Physiology	(Evapo)Transpiration, Cohesion, Adhesion, Capillary Action, Guard Cells, Stomata, Water Potential, Surface Tension
Populations & Community Interactions	Carrying Capacity (K), Logistic Growth, limiting factor, Exponential Growth, rMax, r-selection, k-selection, Density, Density-dependent factor, Density-Independent factor, Mutualism, Parasitism, Symbiosis, Predator, Prey, Batesian Mimicry, Mullerian Mimicry
Community Responses & Energy Dynamics	10% rule, consumer/heterotroph, producer/autotroph, decomposer, GPP, NPP, secondary productivity, Respiration, Photosynthesis Primary Succession, Secondary Succession, Pioneer Species, Keystone Species, Invasive Species, Endemic Species

AP Biology Exam Strategies – Part 1 of the Exam

These are the strategies I have taught students over many years that they say are most helpful on the exam. These are only suggestions and may not work for everybody! Use only if they work for you!

1. **Do easy calculations FIRST OFF** – Most of these are usually easy but students lose the points because they run out of time. Skip the ones you can't do quickly and return if time permits.

2. **SKIP grouped questions** if there are multiple paragraphs and/or data sets to look at. These questions burn a lot of time and are often the most difficult, sometimes just because they LOOK intimidating. Skip them and return when all other MC questions are complete.

**Continue through other multiple choice questions with the following tips in mind:*

a. Question with a **graph/data table/diagram** that has **obvious** information (trend, outcome, etc.)
- Review the figure & mentally summarize
- Read the question or prompt & look for the best answer
- Review text for details if necessary

b. Question with a **graph/data table/diagram** that has **cluttered** information (trends may be present, but need more info. from text to decipher) or **just a picture/pathway**.
- Read the question/prompt
- Review text for more details about what type of answer to look for
- Look for the choice best aligned with the prompt & image

c. Question with **diagrams as choices**
- Read the prompt *carefully*
- Look for best aligned diagram
- Review text for more details if necessary

3. Complete **grouped questions** with multiple data sets/paragraphs
- Read the linked question & answer if possible. If needed, do next step.
- Link **key terms** in choices/question with **related diagram/text information** & answer question.
  - It is helpful to quickly write out the key terms on the page with text/diagrams since usually they are on separate pages.

4. **Make sure all MC questions have been answered or guessed at**

5. Finish more **difficult calculations**

AP Biology Exam Strategies – Part 2 of the Exam

1. Use the 10 minute planning time to **sequence the questions** you will do from easiest to hardest.

2. Pay attention to these **key terms** below:

Term	Applications
Predict	State what you believe will happen based on the data provided or science knowledge
Propose	Usually seen as "Propose a hypothesis/model" that should be linked to the data/content
Justify	Give your reasoning for; should be based on specific prompt-related content "Justify the use of a spectrophotometer for use in photosynthesis studies"
Identify	An answer not requiring an explanation "Identify the primary pigment of photosynthesis" - Chlorophyll
Explain, Analyze & Describe	Answer should give details about how something works, details of a process/phenomenon "Explain/Analyze/Describe how pigments are used in photosynthesis" - Pigments absorb solar energy that cause electrons to flow through ETC…"
Connect	Answer should show the relationship between things/processes "Connect the energy transformations of photosynthesis with those of C. R." - The solar energy absorbed in photo. is used to make chem. energy of glucose which is used in C.R to generate chem. energy of ATP
Evaluate	Discuss the benefits/downfalls/risks of a scenario/method, etc. "Evaluate the use of GMOs in agriculture" "Evaluate the use of this graph for the data"
Pose	Usually seen as "Pose a question" that wants you to develop a scientific question that could be tested or an ethical question that could be addressed
Refine	Change something to be better "Refine the graph to show…"
Construct	Draw, plot, graph, etc. some data you are provided with. Also seen as "Construct an explanation/model", which requires you to describe something
*Claim	As a noun, it means a **statement** based on data, similar to a hypothesis "Make a claim about the role of homework in class performance" - completing homework regularly helps understand material & perform better in class
*Model	As a prompt component, it means many things: A chemical pathway, a graph, a theory, a hypothesis, a stepwise sequence, a cause/effect relationship, etc. **A model is anything that describes natural phenomenon** "Propose a model to connect insulin secretion & BGL" - Negative feedback: Rising BGL causes insulin secretion, falling BGL inhibits insulin production. "Describe 2 parts of a model that connect the processes of Photo. & C.R." - Energy is transformed (Solar → Chemical) - Matter is transformed (CO_2 → Glucose) " Propose a model for how an autoimmune disorder develops based on how a traditional immune response functions" - A step in the pathway is over-activated - A step in T- cell production is defective

Data Interpretation & Analysis

1. Graphs
    a. You are expected to know what types of graphs suit particular types of data
        Line graphs – For trends over **time**
        Bar graphs – For comparing **multiple classes of data**
        Circle graphs – For comparing **parts to a whole**
    b. Graph construction using correct headings, axes, spacing, units, etc.

2. Statistical Analysis
    a. Know which type of data analysis is appropriate
        Standard deviation – determining deviation of all data to each other (spread)
        Standard error – determining deviation from average
        Mean vs. Median – Mean is used when data has no major outliers. If outliers are present, the median measures the average better.
    b. Null hypothesis vs. hypothesis
        Null hypothesis is for comparing expected with observed data
            "There will be no diff. between X & Y"
        Hypothesis is just a generalized prediction based on data/previous knowledge
            " X will happen because Y"
    c. Chi Square
        a. Requires null hypothesis statement
        b. Compares expected & observed values for 2+ data sets
        c. If χ^2 > table critical value, reject null hypothesis, meaning there is a difference between the expected & observed values. Elaborate on what the difference is and why

3. Be sure you review **all the formulas** on the formula sheet and practice using them